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Estimating Asian Elephant Population in Dindugul, Kodaikanal and Theni Forest Divisions, Western Ghats Tamil Nadu

A. Kumaraguru[1], K. Karunanithi[2], S. Asokan[2] and N. Baskaran[3]

[1]*CCMB, Mayiladuthurai, Nagapattinam District, Tamil Nadu, India*
[2]*Dept of Wildlife Biology, A.V.C.College, Mannanpandal, Tamil Nadu, India*
[3]*AERCC, Bangalore, Karnataka, India*

Introduction

The Asian elephant (*Elephas maximus*), an endangered species today, being a wide-ranging animal mainly affected by loss of habitat throughout Asia (Daniel 1987), is in great conflict with humans. Population estimation of elephants in southern India has been carried out extensively using the 'total count' method by the Forest Department since 1970. However, due to several shortcomings like poor visibility in the forested areas, observer fatigue (while covering larger areas like 5 to 10 km^2 blocks), intense labour requirements and several other inherent problems like double counting, the total count method is considered an inappropriate method for obtaining reliable estimates of elephant numbers.

The method proposed by Burnham *et al.* (1980) has been used satisfactorily for estimating elephant densities in Asia through direct counting (Varman & Sukumar 1995; Baskaran & Desai 2000) in areas with high elephant density and enumeration of indirect evidence e.g. dung (Varman *et al*. 1995) in areas with low elephant density and poor visibility.

The Western Ghats hill ranges in southern India are one of the unique biological regions in the world (Myers *et al.* 2000). Elephant Range 9 situated in the Western Ghats, extends over 5700 km^2 located to the south of Palghat gap. Despite the high potential of this region, work on elephants in this proposed area is meagre and hence the present work was undertaken with the following objectives:

- To estimate the population density of elephants in three territorial forest divisions of elephant range 9 in Tamil Nadu.
- To analyse the spatial distribution pattern or abundance of elephants in different vegetation types of the study area and provide recommendations for the future studies of elephants in this landscape.

Methods

Study area

The present study was carried out in three territorial forest divisions, Dindugul, Kodaikanal and Theni, that are located in the Western Ghats of Tamil Nadu, and are a part of Elephant Range 9 declared by Project Elephant, Government of India for the conservation of elephants, situated between 9^0 31' and 10^0 10' N lat. and 77^0 18' and 77^0 46' E long (Fig. 1). The wide variation in rainfall and topography in the study area has resulted in significant diversity of vegetation types (Table 1) that supports a rich floral and faunal diversity.

Estimation of elephant population

Transects were laid across the forest areas covering all the habitats. The sample area was selected by random sampling method, 1:50,000 survey of India topographic map of Dindigul, Kodaikanal and Theni forest divisions with grids of 2.5 x 2.5 km and all grids were numbered and each grid represented a 5 km^2 block. A total of 60 blocks were selected for sampling out of 180 blocks of the study area after excluding blocks that came under human settlements and border areas. A total of 41 transects were laid with a total length of 52.9 km. Within each selected block, a straight 1 km long transect was laid randomly across altitudinal gradients, drainage pattern and human disturbance gradient and transects were surveyed one time.

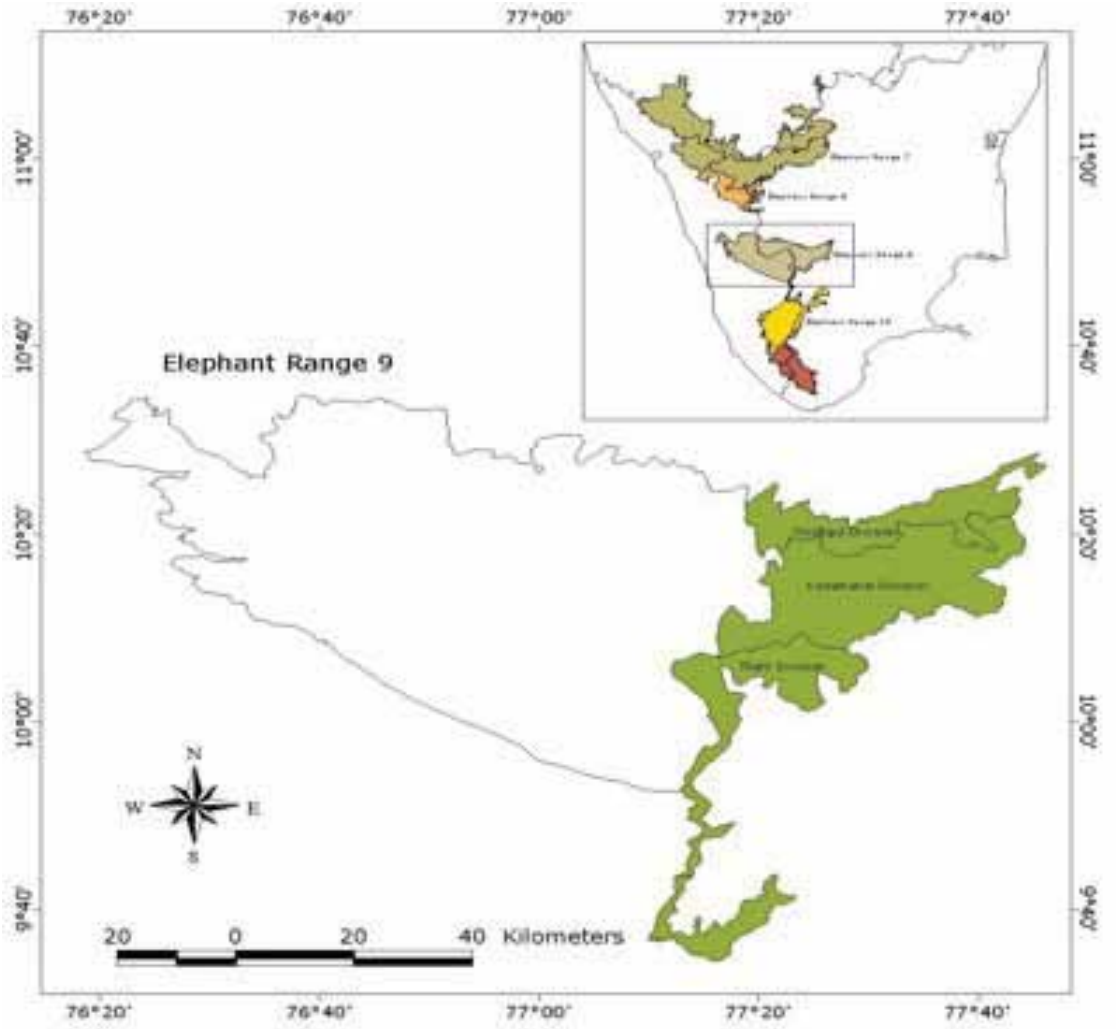

Figure 1. Map of study area showing the various forest divisions surveyed.

The method of Dawson (1991) and Varman *et. al*. (1995) was employed in the present study for estimating the density of elephants and the following formula was used:

$$E = (Y \times r) / D$$

Where, E = density of elephants, Y = density of dung, r = daily rate of decomposition and D = the number of dung piles deposited per elephant per day.

Table 1. Extent [km^2] of various landscape elements in 3 different forest divisions.*

Landscape	Koda-ikanal	Dind-ugul	Theni	Total
Evergreen	69.3	174.3	74.1	317.6
Grassland	70.3	214.8	99.4	384.4
Deciduous	62.2	116.0	47.2	225.4
Scrub	109.5	196.9	86.7	393.1
Tea	3.0	0.3	8.9	12.2
Cultivation	6.0	17.8	116.2	139.9
Total	320.3	720.1	432.5	1472.6

*Source: Tamil Nadu Forest Dept. website.

Dung defection rate (16.16±0.80) calculated in captive elephants of Mudumalai Wildlife Sanctuary was used to convert dung density into elephant density (Watve 1992; Varman *et. al*. 1995). Similarly, a decay rate of 0.0097±0.002 was estimated in similar dry deciduous forest of Mudumalai Wildlife Sanctuary by Varman *et al*. (1995). It is assumed that there will be no variation in defecation and decay rates between Dindigul and Theni forest divisions used in the present study.

Data collected from line transects was first used to calculate the dung density, and incorporating the dung decay rate and defecation rate, the dung density was converted into elephant density. Dung piles that were visible from lines were counted, for each dung pile; perpendicular distance from line to centre of dung piles was measured using measuring tape, with (±1 cm) accuracy. All the analyses were performed using computer software *GAJAHA ver.1.0* – a Monte

Table 2. Elephant density and population size estimated using line transect dung count method in three different forest divisions.

Forest Division	Transect length [km]	# dung piles	Dung density [dung/km^2]	Elephant density [elephants/km^2]		Elephant habitat* [km^2]	Esti-mated pop.
				Mean±SD	95% CI		
Theni	14.30	90	539±58.54	0.32±0.05	0.26-0.37	132	42
Dindugul	19.00	310	1266±77.76	0.76±0.11	0.64-0.87	108	82
Theni & Dindugul	33.30	400	957±50.97	0.57±0.32	0.49-0.65	240	137
Overall**	52.95	402	603±32.10	0.36±0.16	0.31-0.42	300	108

*From Tamil Nadu Forest Department website.

**Including Kodaikanal Forest Division, density for Kodaikanal was estimated separately due to very low sample size (n=2) in nearly 20 km of transect.

Carlo simulation method developed by Santosh and Sukumar (1995).

The density or abundance of elephants in each habitat type was evaluated using dung count data collected for population estimation. The transect lines were laid in different habitat types in proportion to their availability. The dung density was calculated to find out its abundance in different vegetation types.

Results

Overall elephant population

A total of 402 dung piles were recorded from a transect of 52.75 km length. This works out to about 8 dung piles per kilometre of transect.

The analysis was carried out using a cut-off point of 15 m, as distribution of dung piles from the line transect appeared normal (Fig. 2) up to this distance. The pooled data of three transects indicated a mean density of 0.36 elephants/km^2 with a narrow confidence interval of 0.31 to 0.42 elephants/km^2. The pooled data of the three forest divisions may be considered more appropriate as the standard error was 32.10. Thus the present study indicated the density of elephants is 140 elephants/km^2. However, the present study report on elephant density needs further confirmations.

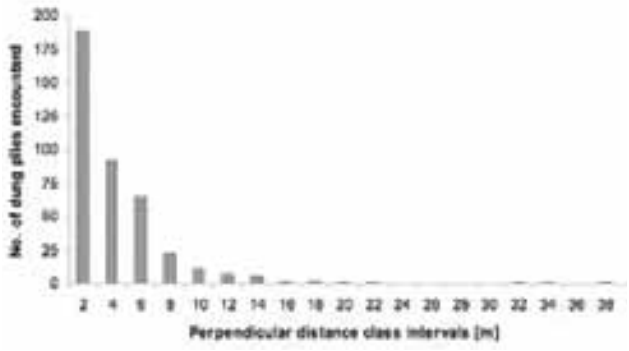

Figure 2. Distribution of perpendicular distances of elephant dung piles into 2 m class intervals.

Elephant density in different forest divisions

The results of the density analysis showed a considerable variation with Dindugul forest division (0.76 elephants/km^2) having more than double the density of Theni forest division (0.26 elephants/km^2). On the whole, 82 elephants were estimated in Dindugul forest division and 42 elephants in Theni division (Table 2).

Eelephant density in different vegetation types

To examine distribution pattern of elephants in different vegetation types, the vegetation used by the elephants in Theni and Dindugul forest divisions was classified broadly into the following four major types Viz., Teak Plantation, Grassland, Dry deciduous forest of Thorn forest. Considering sample size (number of dung piles required for reliable estimate) and elephant ecology. The data from Kodaikanal was not included in the analysis as sample size obtained for this division was very low (n =2) and also the forest type (wattle "*Acacia mearnsii*" plantation) in which these two dung piles were recorded was not found in the other two forest divisions surveyed.

The analysis revealed that among the four vegetation types studied, elephant spatial distribution or abundance appeared to be more in grassland followed by teak plantation, dry deciduous and thorn forests (Table 3, Fig. 3).

Table 3. Elephant density in various forest types at Theni and Dindugul.

Forest type	Transect length [km]	# dung piles	Dung density [dung/km^2]	Elephant density [elephants/km^2]	
				Mean	95% CI
Teak plantation	1.30	19	1355±394.10	0.82	0.61-1.01
Grassland	2.75	45	1275±210.24	0.77	0.62-0.90
Dry deciduous forest	14.10	197	1033±61.35	0.61	0.52-0.70
Thorn forest	14.30	134	795±70.84	0.48	0.40-0.54
Overall	32.45	395	1114.5±184.1	0.67	0.54-0.79

However, encounter rates of elephant dung piles is a function of visibility that varies widely between forest types (given the equal distribution of elephants in various habitats). Encounter rate is related to the transect width.

The results of density analysis showed that elephant abundance varied considerably (0.48 to 0.82 elephants/km^2) across the four different habitats with highest in teak plantation forest and lowest in thorn forest (Table 3).

Discussion

Elephant population

The results of the present investigation suggest that there is an unequal spatial distribution or abundance of elephants across the four vegetation types during the study period. Such unequal distribution could be attributed to the uneven distribution of various resources like food, water, shelter etc. *Sivaganesan* (1991) also reported seasonal movement changes in elephant density in different vegetation types.

Using the line transect dung count method, the present study estimated a mean density of 0.36 elephants/km^2 and a total population of 108 elephants. The accuracy and precision of population estimates in line transect sampling method depends on the sampling area distribution, sampling intensity and sample size. The narrow difference between the lower (0.31 elephants/km^2) and upper (0.42 elephants/km^2) densities at 95% confidence interval indicates a high precision of the present estimate. The results obtained using three division data would be more appropriate to consider instead of overall estimate arrived at using two division data excluding Kodaikanal, as the standard error of dung density estimated in the analysis of three divisions together was smaller (32.10) as compared to two divisions (50.97).

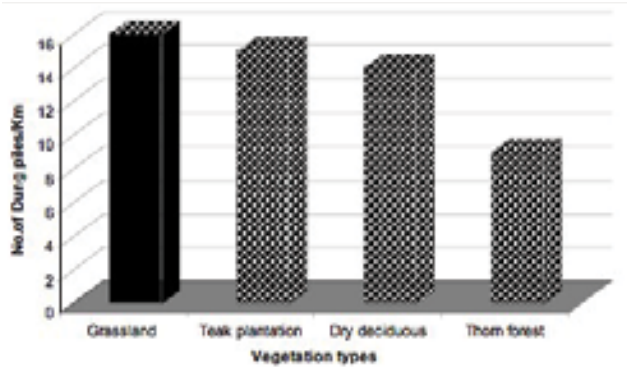

Figure 3. Encounter rate of elephant dung piles in various forest types in Theni and Dindugul.

On the whole, in the present study area (~1470 km^2) 108 elephants were estimated (with three divisions together). The present estimate of 0.36 elephants/km^2 or 108 elephants for the three divisions together is comparable with the estimate of 112 elephants made by Forest Department during 2002 synchronized elephant census (using block count method) or 85 elephants (65 from dung count average of Dindugul and Theni division and 20 from block count in Kodaikanal division) conducted during the study period.

The small variation in the population size estimates using dung count method between the present study and earlier estimates by the Forest Department could be due to any one or a combination of following reasons. The field surveys for the current study were carried out during January to April unlike the earlier estimate during 2002 that was done in early May. It has been well documented that elephants tend to move between habitats according to seasons both in Asia (Baskaran & Desai 2000; Kumaraguru 2006) and in Africa (Field 1971).

Spatial distribution of elephants in different vegetation types

Based on the results of the present investigation, it can be concluded that the dry deciduous forest with higher sampling area (14.1 km) and sample size (197 dung piles) are supporting a high elephant density (0.61 elephants/km^2). Thus the present study results are similar to that of Sivaganesan (1991). The reason for the dry deciduous forest to have high density could be due to the availability of grass resources coupled with shade and water during the dry season. Studies on feeding behaviour on elephants in Asia (Sivaganesan 1991) also showed that grass is the major diet of elephants. Abundant availability of such grass resources in the dry deciduous forest could have resulted in the higher concentrations of elephants.

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Corresponding author's e-mail: Wildlife_guru@yahoo.com